Transport Layer
(Part 1)

ETSF10 – Internet Protocols – 2011

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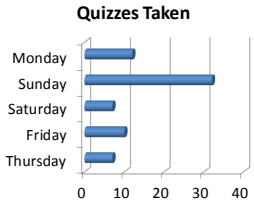
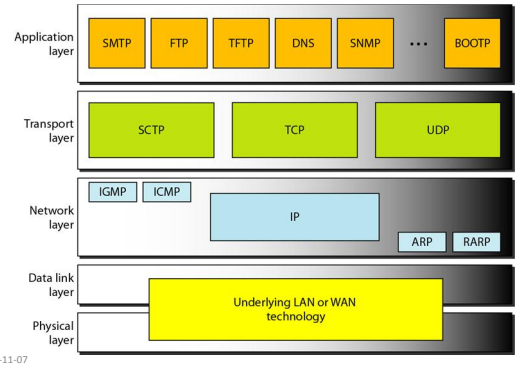
Department of Electrical and Information Technology

To do now: ”One minute paper”

- Quiz #1 completed
  - Attendance: **68**
- What was the most difficult question?
  - Discuss in pairs
  - Write it down



TCP/IP model



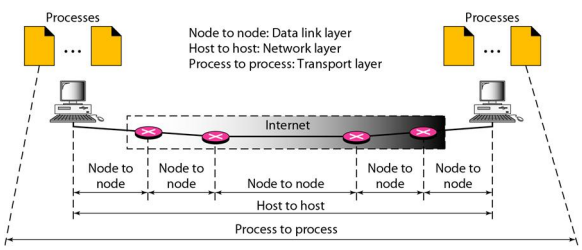
Transport Layer

- **Process-to-process delivery** §23.1
- **User Datagram Protocol (UDP)** §23.2
- **Transmission Control Protocol (TCP)** §23.3
- Network performance §3.6
- Congestion control §24.1-4
- Quality of Service (QoS) §24.5-6
- Real-time interactive audio/video §29.5

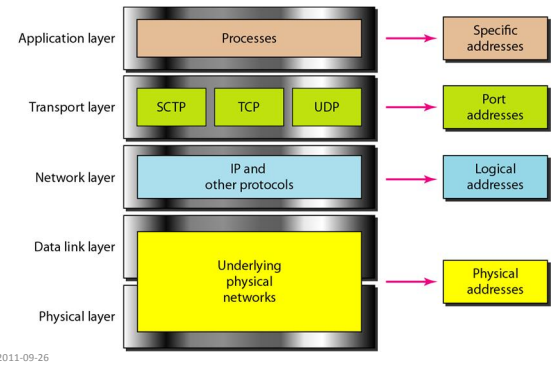
Transport Layer

- Communication between applications
- Client/server concept
  - Local host
  - Remote host
- Process-to-process delivery
  - Same host
  - Multiple applications

Process-to-Process Delivery



Addressing in TCP/IP



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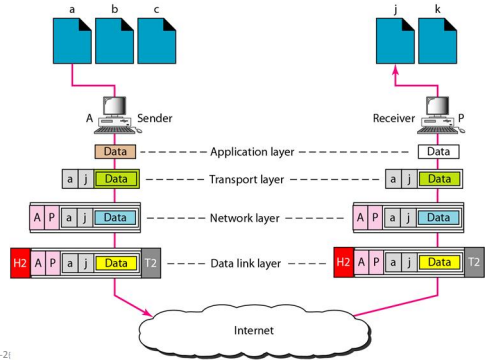
Logical and port addresses



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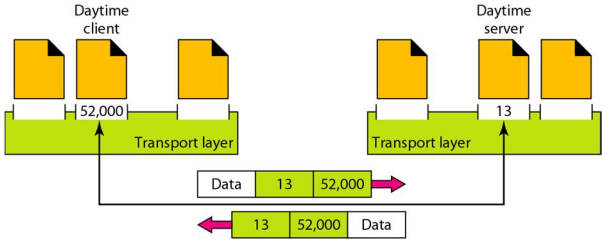
Addressing the processes

Å Port numbers



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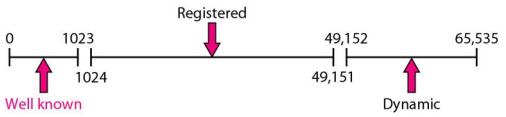
IANA ranges

Å Internet Assigned Number Authority

ï Organises port number usage



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A few well-known ports (UDP)

Port	*Protocol*	*Description*
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
53	Nameserver	Domain Name Service
67	BOOTPs	Server port to download bootstrap information
68	BOOTPc	Client port to download bootstrap information
69	TFTP	Trivial File Transfer Protocol
111	RPC	Remote Procedure Call
123	NTP	Network Time Protocol
161	SNMP	Simple Network Management Protocol
162	SNMP	Simple Network Management Protocol (trap)

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A few well-known ports (TCP)

Port	*Protocol*	*Description*
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
20	FTP, Data	File Transfer Protocol (data connection)
21	FTP, Control	File Transfer Protocol (control connection)
23	TELNET	Terminal Network
25	SMTP	Simple Mail Transfer Protocol
53	DNS	Domain Name Server
67	BOOTP	Bootstrap Protocol
79	Finger	Finger
80	HTTP	Hypertext Transfer Protocol
111	RPC	Remote Procedure Call

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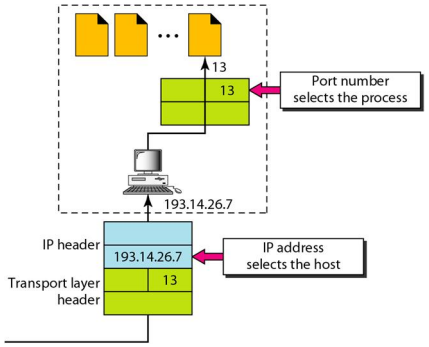
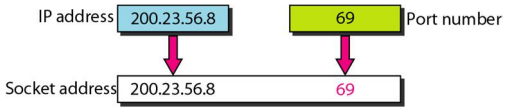
IP addresses and port numbers



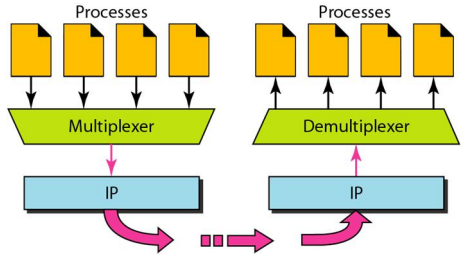
Socket addresses

- Combination of IP & port
  - Unique for each process



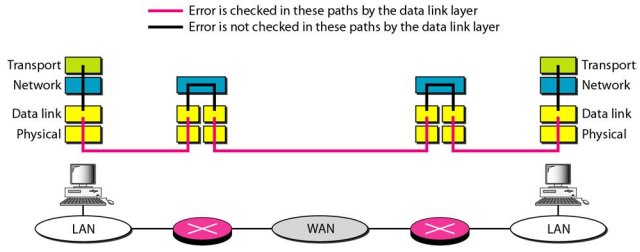
Multiplexing and demultiplexing

- One transport layer protocol
- Many applications



Error control

- Reliable transport layer service
- Provided by TCP



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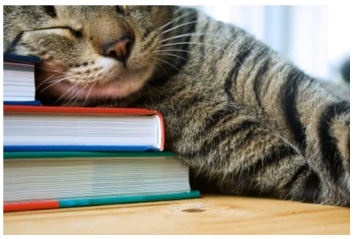
See you in 15' :)



- After the break
  - UDP
  - TCP

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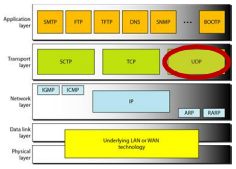
User Datagram Protocol (UDP)

- Connectionless
  - Independent datagrams
  - No sessions
- Unreliable
  - No error control
  - No flow control



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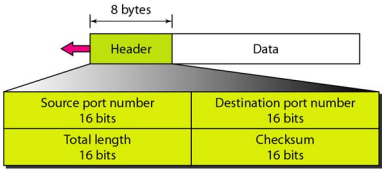
UDP header format



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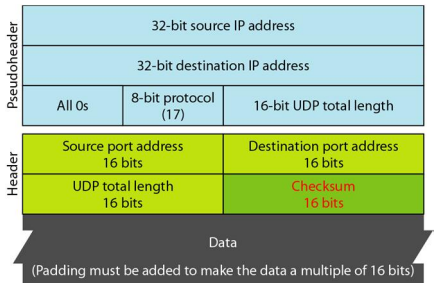
Error checking

- Checksum (optional)



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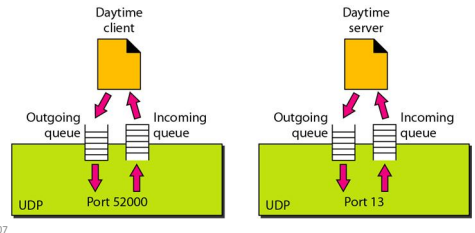
Implementation of ports

- Different for clients and servers
  - Queues
  - ICMP



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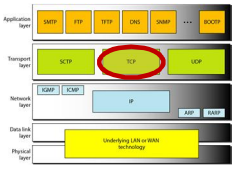
Transmission Control Protocol (TCP)

- Connection-oriented
  - Sessions
  - Byte stream service
- Reliable
  - Flow control
  - Error control
    - Retransmissions
  - Congestion control



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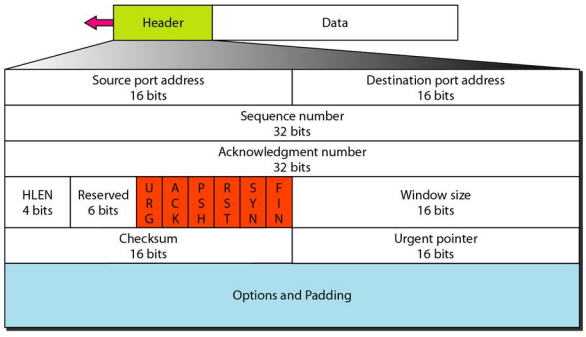
TCP header format



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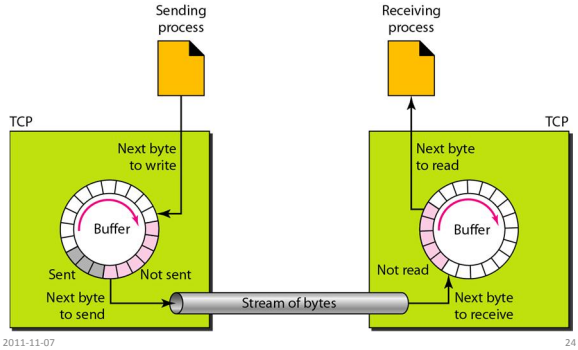
Sending and receiving buffers



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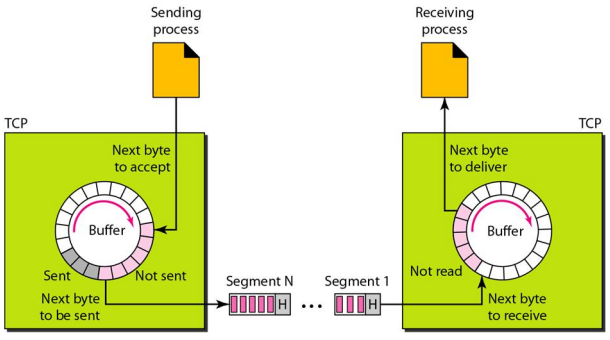
Segments



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Sequence numbers

Segment 1	→	Sequence Number: 10,001 (range: 10,001 to 11,000)
Segment 2	→	Sequence Number: 11,001 (range: 11,001 to 12,000)
Segment 3	→	Sequence Number: 12,001 (range: 12,001 to 13,000)
Segment 4	→	Sequence Number: 13,001 (range: 13,001 to 14,000)
Segment 5	→	Sequence Number: 14,001 (range: 14,001 to 15,000)

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TCP operation

- Connection establishment
  - Three-way handshake
- Data transfer
- Connection termination
  - Three-way handshake
  - Half-close

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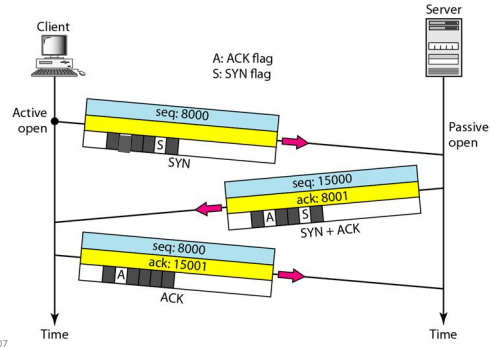
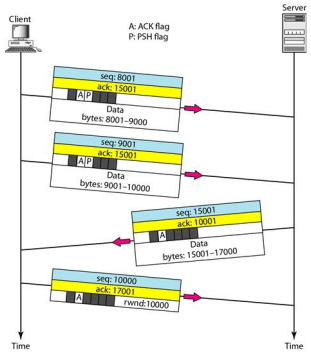
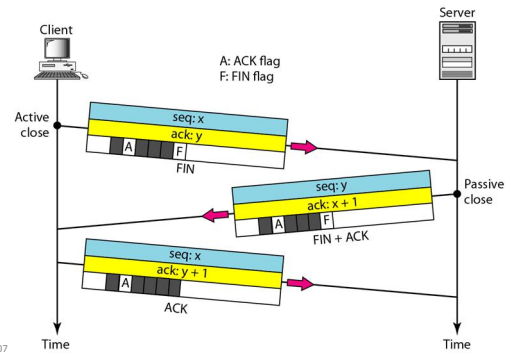
Connection establishment



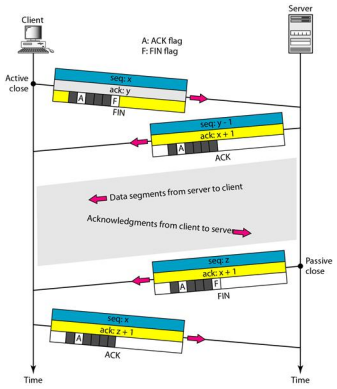
Data transfer



Connection termination



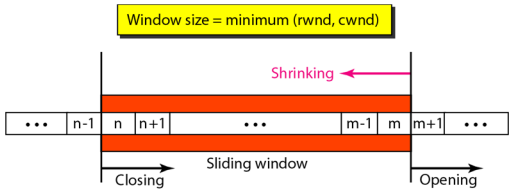
Half-close



Flow control

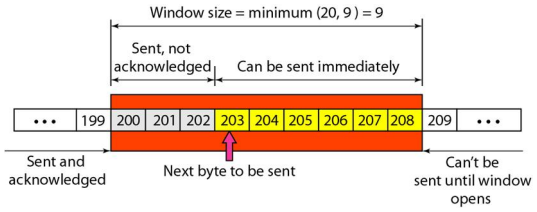
- Sliding window
  - Known from data link layer
- Hybrid implementation
  - Go-back-N
  - Selective repeat
- Byte oriented
  - Bytes in segment as units
- Variable size

Sliding window



Sliding window

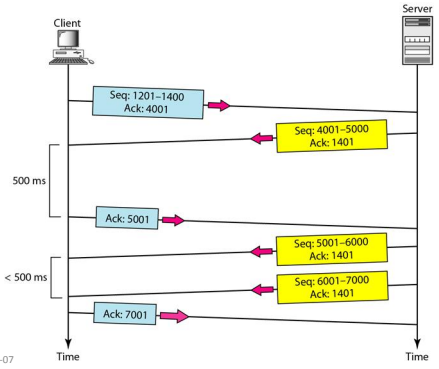
- Window size = min(rwnd,cwnd)



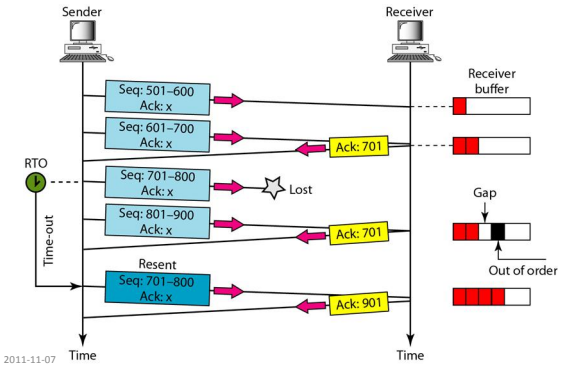
Error control

- Checksum
- Acknowledgement
  - ACK recieved data
- Retransmission
  - After time-out
    - RTO = f(RTT)
  - After 3 duplicate ACK
    - Fast retransmission

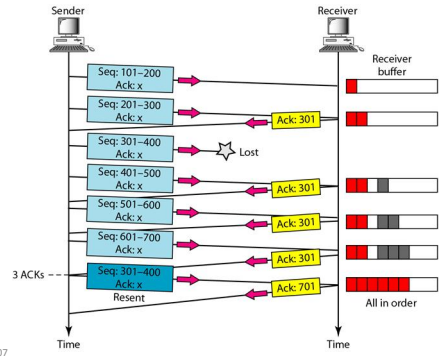
Normal operation



Lost segment



Fast retransmission



Tomorrow's lecture

- **Network performance** §3.6
- **Congestion control** §24.1-4
- **Quality of Service (QoS)** §24.5-6
- **Real-time interactive audio/video** §29.5

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Introduction to the TCP lab